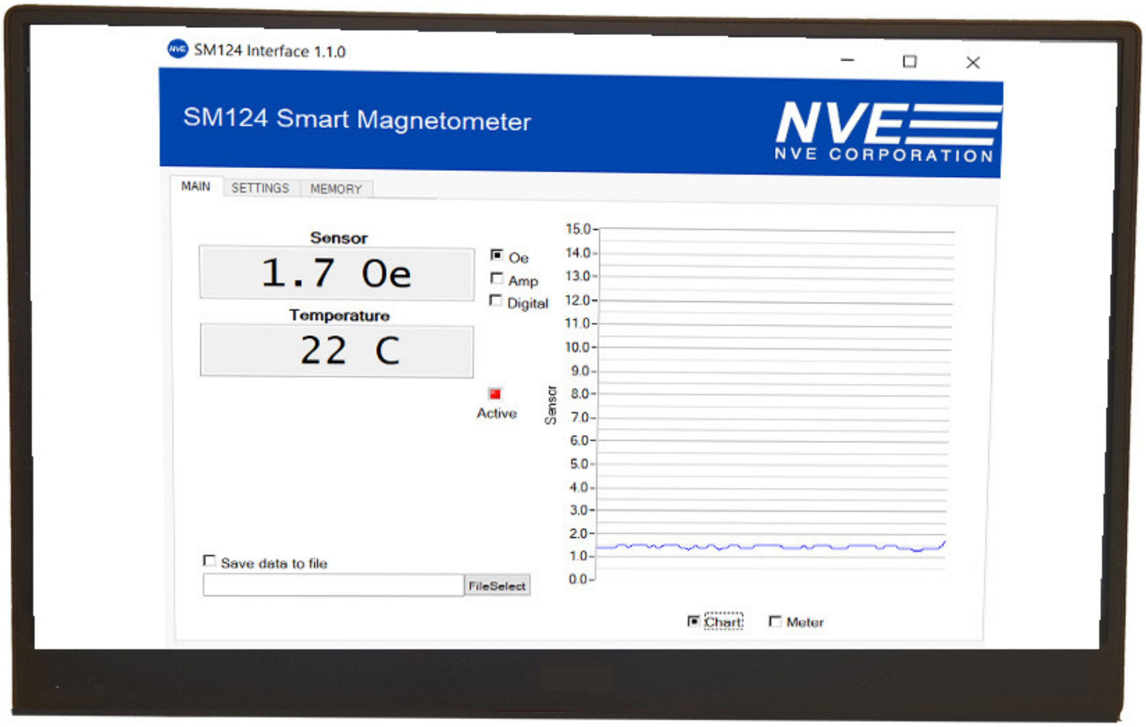
AG952: SM124 Smart I²C GMR Magnetometer Evaluation Board



Summary

The AG952 Evaluation Board provides an easy-to-use interface for the SM124-10E Smart Magnetometer. The evaluation kit includes:

- USB-powered Evaluation Board with:
  - an SM124-10E GMR Magnetometer sensor
  - a microcontroller connected to the sensor via I²C
  - a regulated 3.3 volt supply to power the SM124-10E
  - a current-carrying trace under the sensor for evaluating as a current sensor

- A small ceramic magnet for evaluating as a proximity sensor
- USB cable to connect the Evaluation Board to a computer
- User interface software (download from https://github.com/NveCorporation)

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

Contents

1. Overview

This Evaluation Kit Includes:

- An evaluation board including:
  – An SM124-10E Smart Magnetometer
  – A microcontroller
  – A USB computer interface

- Easy to install Windows-compatible user interface software via our GitHub repository

- A disk magnet.

- USB to mini-B cable

SM124-10E Features:

- Can detect magnets more than 50 mm away
- Slick single-byte communication interface
- I²C and digital threshold outputs
- In-plane sensitivity more usable than Hall effect sensors
- Programmable offset and gain correction
- Single-byte addresses and parameters to simplify firmware development
- Two hardware selectable I²C addresses
- Internal temperature compensation
- Optional magnet temperature calibration
- 2.2 to 3.6V supply
- 3.3 or 5V compatible I²C interface
- Ultraminiature 2.5 x 2.5 x 0.8 mm TDFN6 package

SM124-10E Key Specifications:

- 8 bit (<1%) output resolution
- 0 to 10 Oe (1 mT) range for high sensitivity
- –40°C to +125°C operating range
- 5% accuracy from 0 to 85°C
- 10 kSps sample rate for fast response
- 6 mA typical supply current

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

2. Quick Start

2.1. Connect the Evaluation Board to a computer via the USB cable.

2.2. Apply a magnetic field with the disk magnet included in the kit and verify that the LED turns on:

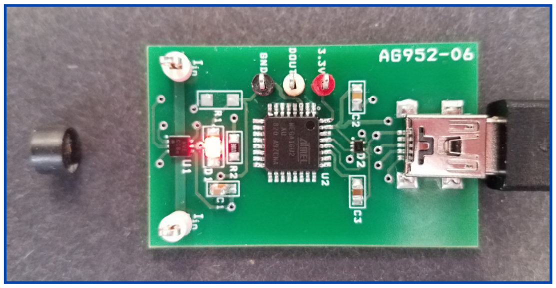


Figure 1. Activating the SM124 sensor with a disk magnet.

2.2. Download the AG952 software from our GitHub repository (*https://github.com/NveCorporation*).

2.3. Install the software and launch the application.

2.4. The user interface will show the applied field, which can be changed by moving the magnet relative to the sensor.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

3. The Evaluation Board

3.1 Board Layout

The evaluation board communicates with a host computer via USB and a Smart Magnetometer via I²C:

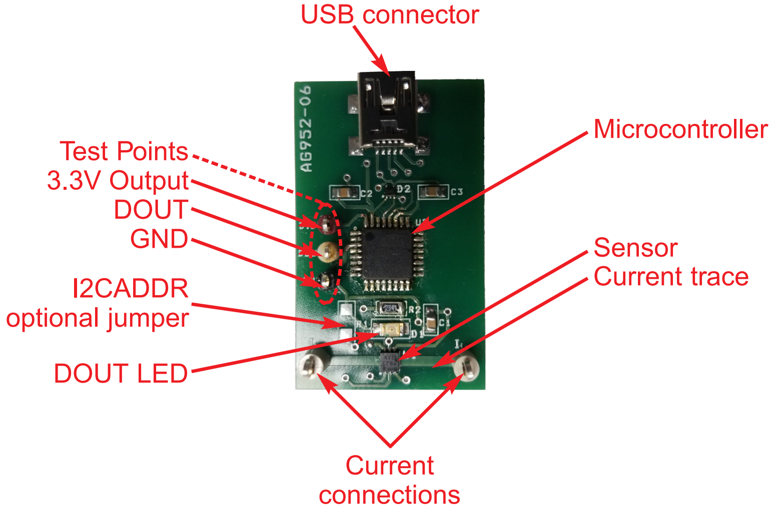


Figure 2. The Evaluation Board (actual size).

Part Number	Designator	Manufacturer	Qty	Description
		Board-Level Components		
SM124-10E	U1	NVE Corporation	1	SMART MAGNETOMETER SENSOR, 15 OE
ATMEGA16U2-AU	U2	Microchip Technology	1	IC MCU 8BIT 16KB FLASH 32TQFP
APT3216LSECK/J3-PRV	D1	Kingbright	1	LED RED CLEAR 1206 SMD
1206	R1	Generic	1	0-OHM JUMPER (DNP)
0805	R2	Generic	1	RES 3K OHM 1% 1/4W 0805
TPD2E001DRLR	D2	Texas Instruments	1	TVS DIODE 5.5V SOT5
885012207016	C1, C2	Wurth Electronics Inc.	2	CAP CER 0.1UF 10V X7R 0805
GRM21BR71C105KA01I	C3	Murata Electronics North An	1	CAP CER 1UF 16V X7R 0805
690-005-299-043	J1	EDAC Inc.	1	CONN MINI USB RCPT RA TYPE B SMD
500x	3.3V, GND, DOUT	Keystone Electronics	3	TEST POINT PC MINI .040"D
5007	Iin	Keystone Electronics	2	TEST POINT PC COMPACT .063"D WHT
		Package-Level Components		
12216	N/A	NVE Corporation	1	6 MM DIA. X 4 MM THICK DISK MAGNET
	N/A	Generic	1	3ft FLAT USB 2.0 480Mbps Type A Male to Mini-B/5-Pin Male Ca

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

3.2 Schematic

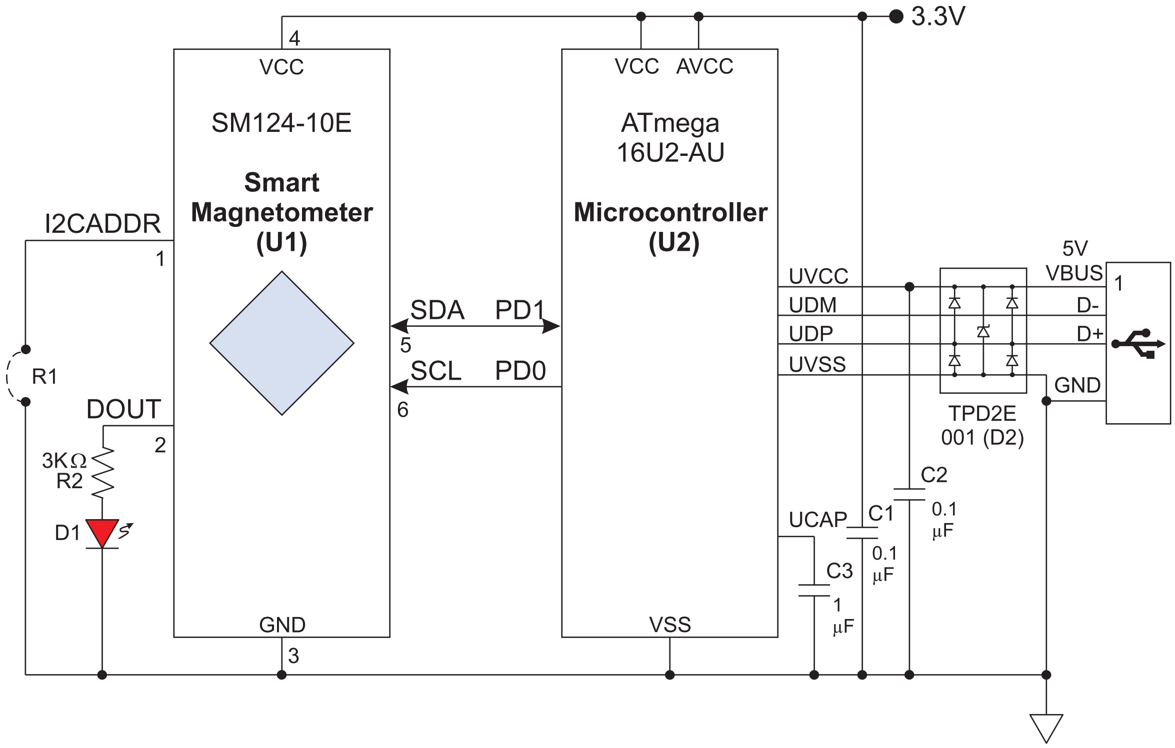


Figure 3. Evaluation Board Schematic.

3.3 Circuit Description

The Sensor

The SM124 (U1) is a six-pin component, with power (VDD and GND); I²C (SCL and SDA), the DOUT digital threshold output, and the I2CADDR pin to set the part's slave address.

Microcontroller

The SM124 is compatible with any microcontroller. This evaluation board uses a popular ATMEGA16U2 8-bit microcontroller (U2), which has integrated I²C and USB interfaces.

The microcontroller also has an internal 3.3-volt regulator, which is used to power the sensor.

I²C

I²C links the sensor and microcontroller. The SM124 is an I²C Slave, and the microcontroller is configured as the Master. The SM124 I²C interface is compatible with 3.3 or five-volt microcontrollers. The evaluation board uses 3.3 volts for both the sensor and five-volts for the microcontroller.

Setting the I²C Address

By default, the I2CADDR line is left unconnected (R1 unpopulated) and the default I²C address is then 72 dec (48 hex). Instaloling a jumper (R1) to ground change s the sensor's I²C to 16 dec (10 hex).

USB Interface

The microcontroller has an integrated USB UART. A Transient Voltage Suppressor (D2) protects the microcontroller.

Current-Sensing Trace

The board has a current trace under the sensor IC (I_{in} connections) for evaluating the magnetometer as a current sensor. The trace is 0.05 inches (1.3 mm) wide and one-ounce copper, and can carry up to 5 amps with a safe temperature rise.

LED

Red LED D1 shows when the digital output (DOUT) is activated. A resistor (R2) sets the LED brightness.

Decoupling Capacitors

The board has 0.1 µF decoupling capacitors (C1 and C2) as recommended for the sensor and USB bus supply, and a 1 µF decoupling capacitor (C3) as recommended for the microcontroller's internal 3.3-volt regulator.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

4. Magnets and Magnetic Operation

The Evaluation Kit includes a popular ferrite disk magnet. The magnetic field from the magnet at the center of the sensor is shown in this graph:

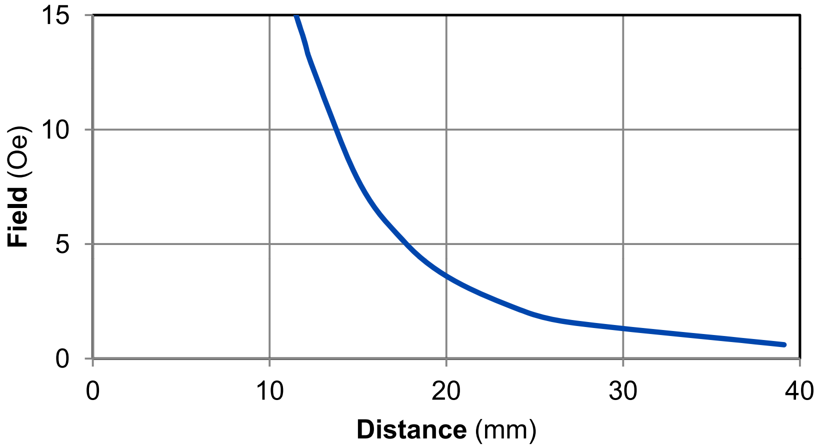


Figure 4. Magnetic field from the 6 mm dia. x 4 mm thick ferrite magnet
(referenced to the center of the sensor).

Larger and stronger magnets allow farther operate and release distances. For more calculations, use our axial disc magnetic field versus distance Web application at:

www.nve.com/spec/calculators.php#tabs-Axial-Disc-Magnet-Field.

4.1 Magnetic Thresholds

The default magnetic threshold is 10 Oe, and common thresholds are 4 to 10 Oe. Thresholds even lower than 4 Oe can be programmed, although care must be taken to account for the earth's magnetic field, which is typically on the order of 0.5 Oe.

The magnetic threshold is expressed as a percentage of the sensor's range, and can be changed by writing to the appropriate address in the sensor's nonvolatile memory. The magnetic hysteresis can also be set.

Typical thresholds for proximity sensing with the magnet included in the kit are shown in the following table:

Parameter		Activation field	Nominal magnet distance
Threshold	Hysteresis		
100%*	10%*	13 Oe	12.5 mm
50%	5%	5 Oe	18 mm
20%	2%	2 Oe	24 mm

*Factory defaults

Table 1. Typical proximity-sensing settings.

4.2 Temperature Compensation

The sensor is factory calibrated and temperature compensated to accurately read magnetic field over temperature. The default reading is the temperature-compensated number. The uncompensated output can be read from a different address.

4.3 Magnet Temperature Compensation

In addition to sensor element temperature compensation, outputs are available that also compensate for the decrease in magnet strength at higher temperatures. Two corrections are calculated: one for low-cost ferrite magnets and another for high field rare-earth magnets.

Reading from a particular temperature compensation profile also sets the magnetic threshold to use that profile.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

5. Current Sensing

SM124-10E sensors can measure the current through a circuit board trace by detecting the magnetic field generated by the current through the trace this application. The digital output can be used for current threshold detection or overcurrent protection.

The evaluation board includes a current-sensing trace:

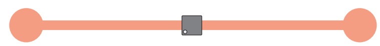


Figure 5. Current trace (top view).

The board trace is on the top side of the circuit board for high current sensitivity, but traces can also be run on the bottom side of the PCB for higher currents. The magnetic field generated in either case can be approximated by Ampere's law:

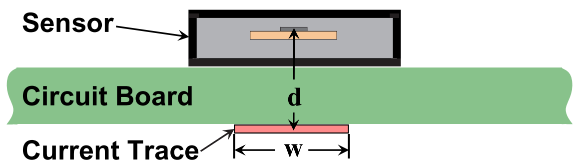


Figure 6. Current-sensing over a circuit board trace (side view).

$$H = \frac{2I}{d}$$ ["H" in oersteds, "I" in amps, and "d" in millimeters]

For the trace on the top of the circuit board, "d" is the distance from the bottom of the sensor package to the sensor element, which is 0.7 millimeters. The field is therefore approximately 3 Oe/A, and is linear to approximately 10 Oe or 3.5A.

Typical parameters for overcurrent sensing are summarized in the following table:

Parameter		Current Threshold	
Threshold	**Hysteresis**	**On**	**Off**
100%	90%	3.5 A	0.35 A
30%	27%	1 A	0.1 A
15%	5%	0.5 A	0.35 A

Table 2. Typical overcurrent detection settings.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

6. User Interface Software Installation

6.1 System Requirements

The software system requirements are:

- Windows 7 or later
- 100 MB of system memory
- One USB 2.0 port
- Monitor (minimum 800 pixels vertical)

6.2 Software Installation

6.2.1. Download the software installation package from ***https://github.com/NveCorporation***

6.2.2. Run ***setup.exe*** to begin installation.

6.2.3. Follow prompts for installing the NVE software application and supporting National Instruments files.

6.3 USB driver installation

6.3.1. Disconnect any AG952 boards connected to the PC.

6.3.2. Locate the USB driver ***NVESmartSensor.inf*** in the ***drivers*** folder of the installation package.

6.3.3. Right click on ***NVESmartSensor.inf*** and click "Install."

6.3.4. Re-start the computer to complete the installation.

6.3.5. Connect the AG952 board to a USB port.

6.3.6. The connection can be verified by checking for "NVE Smart Sensor" under
"Ports (COM & LPT)" in Windows Device Manager.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

7. User Interface Operation

The User Interface allows reading sensor data, setting the digital output threshold, and reading and writing the nonvolatile sensor calibration constants.

After starting the application, a single window with three tabbed panels is displayed. The three tabs are:

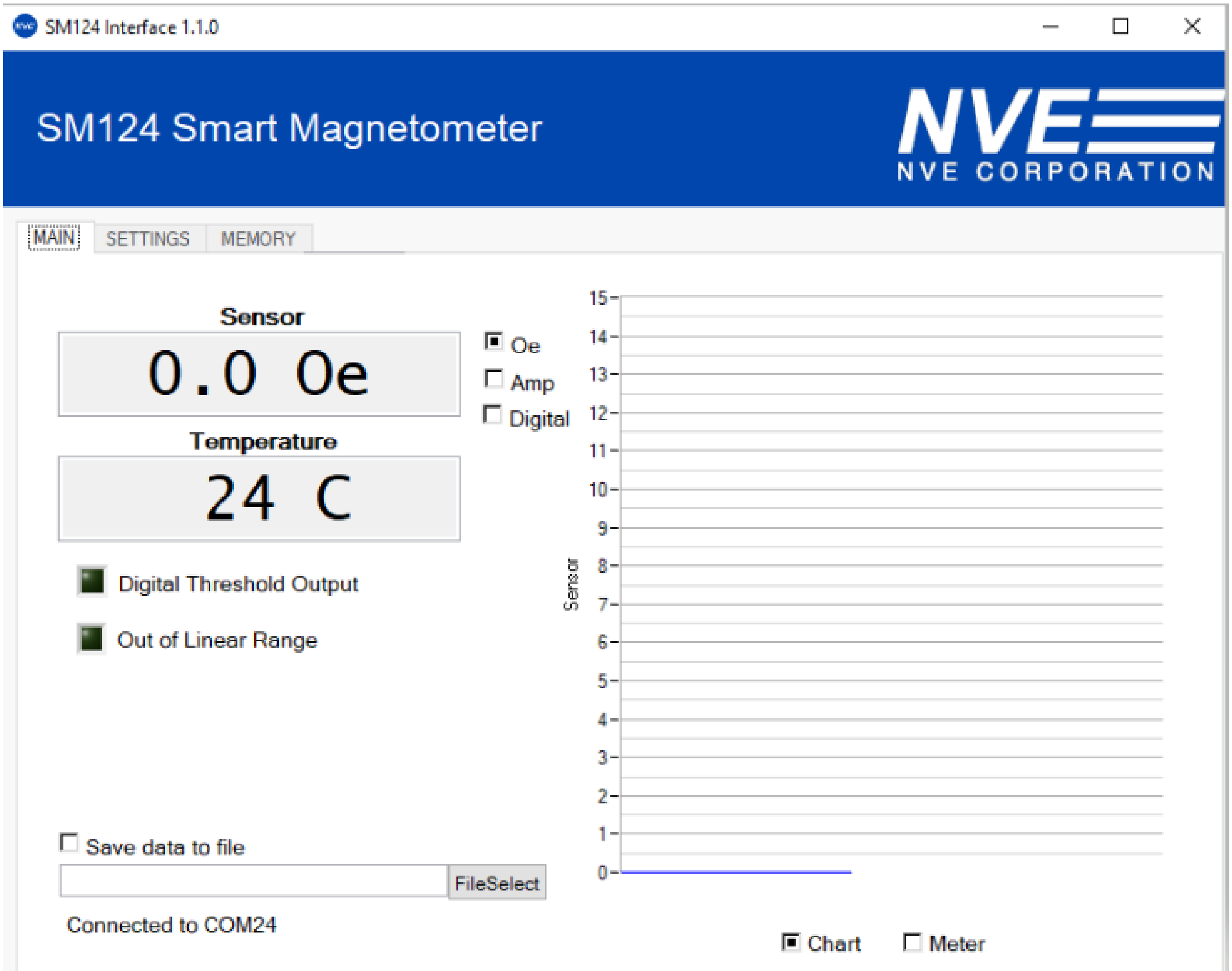
1. Main – Displays measurement results in both digital and graphical formats.

2. Settings – A graphical interface to change the digital output threshold and its hysteresis.

3. Memory – A table shows the sensor's data and calibration constants. Constants can be changed by double-clicking on the appropriate cell. Type in a new number and hit "Enter."

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

7.1. Main Tab



Main tab elements are described below:

Upper Digital Display – Displays the output of the device in either Oersteds or Amperes. Double right-clicking on the display changes the precision.

Lower Digital Display – Displays the calibrated temperature from the sensor in degrees Celsius.

Oersteds – Sets upper display to Oersteds.

Amperes – Sets the upper display to Amperes.

Digital – Sets lower and upper displays to either hexadecimal or decimal.

Chart – Displays a "strip chart" on right side of the tab showing the measurement on the y-axis. The chart is updated with each measurement.

Meter – Displays a virtual meter on the right side of the tab.

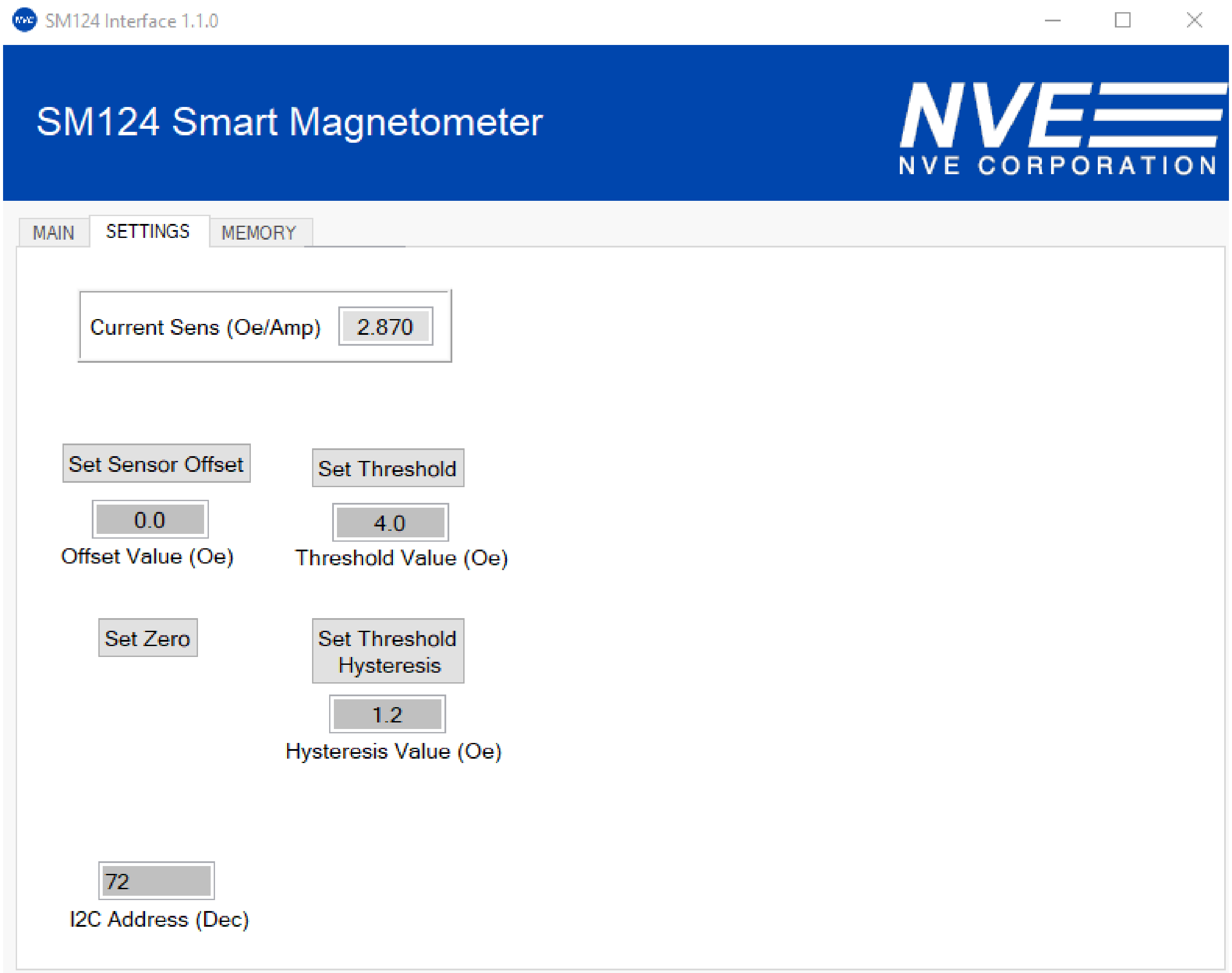
Save Data to File – Checking this box saves the datapoints to a file chosen under the *File Select* button.

File Select – Opens a pop-up window to select the data file.

Digital Threshold Output – A virtual LED turns on when the sensor reading is above the threshold. The threshold and hysteresis can be set in the Settings Tab.

Out of Linear Range – Indicates the magnetic field exceeds sensor's linear range.

7.2. Settings Tab



Set Sensor Offset – This button sets the sensor offset, which is useful for zeroing out background magnetic fields.

Set Zero – Sets the sensor offset to the present sensor output.

Set Threshold – Sets the sensor's digital output (DOUT) turn-on threshold.

Set Threshold Hysteresis – Used to change the magnetic threshold differential located in the nonvolatile memory. The digital output will turn off at *Threshold – Hysteresis.*

I2C Address – The sensor's I²C slave address in decimal format.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

7.3. Memory Tab

SM124 Interface 1.1.0

SM124 Smart Magnetometer

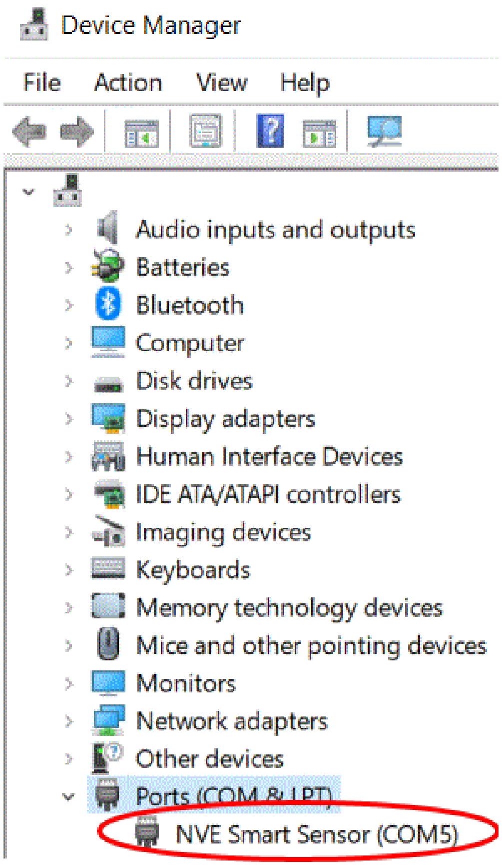
NVE CORPORATION

MAIN SETTINGS MEMORY

Address (Hex)	Name	Value (Hex)	Value (Dec)	Description
0	Sensor	0000	0	Sensor (calibrated) (% of 10 Oe /1 mT)
1	Sensor_Fe	0000	0	Sensor output corrected for a ferrite magnet (% of 10 Oe /1 mT)
2	Sensor_Nd	0000	0	Sensor output corrected for neodymium magnet (% of 10 Oe/1 mT)
3	Sensor_Raw	0000	0	Sensor (uncalibrated)
4	Temp	001B	27	Temperature (°C)
5	DOUT	0000	0	Digital Output
6	I2CADDR	0048	72	I2C Address
20	Threshold	0028	40	Sensor digital threshold (% of 10 Oe /1 mT)
21	Hysteresis	0009	9	Magnetic threshold differential (% of 10 Oe /1 mT)
22	DOUT_Invert	0001	1	Digital output invert (High to invert DOUT)
23	Sensor_Offset	00D0	-48	Sensor offset (% of 10 Oe /1 mT)
24	Sensor_Sens	0055	85	Sensor sensitivity (% of spec)
25	Tempco	0058	88	Temperature coefficient of sensitivity (% of spec)
26	Temp_Offset	0000	0	Temperature sensor offset (°C)
27	Temp_Slope	0063	99	Temperature slope (Temp. cal. curve %)
28	m	0008	8	Digital filter constant (m=1 disables filter)
29	I2C_Pullups	0000	0	Enable pull-ups (1=enabled, 0=disabled)

8. Troubleshooting

- No communications
  - Check USB cable.
  - Verify USB port under Windows Device Manager:



  - Reinstall the USB driver.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

9. Revision History

SB-00-076-A	**Change**
December 2018	• Initial Release

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

Datasheet Limitations
The information and data provided in datasheets shall define the specification of the product as agreed between NVE and its customer, unless NVE and customer have explicitly agreed otherwise in writing. All specifications are based on NVE test protocols. In no event however, shall an agreement be valid in which the NVE product is deemed to offer functions and qualities beyond those described in the datasheet.

Limited Warranty and Liability
Information in this document is believed to be accurate and reliable. However, NVE does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

In no event shall NVE be liable for any indirect, incidental, punitive, special or consequential damages (including, without limitation, lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Right to Make Changes
NVE reserves the right to make changes to information published in this document including, without limitation, specifications and product descriptions at any time and without notice. This document supersedes and replaces all information supplied prior to its publication.

Use in Life-Critical or Safety-Critical Applications
Unless NVE and a customer explicitly agree otherwise in writing, NVE products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical devices or equipment. NVE accepts no liability for inclusion or use of NVE products in such applications and such inclusion or use is at the customer's own risk. Should the customer use NVE products for such application whether authorized by NVE or not, the customer shall indemnify and hold NVE harmless against all claims and damages.

Applications
Applications described in this datasheet are illustrative only. NVE makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NVE products, and NVE accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NVE product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customers. Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NVE does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customers. The customer is responsible for all necessary testing for the customer's applications and products using NVE products in order to avoid a default of the applications and the products or of the application or use by customer's third party customers. NVE accepts no liability in this respect.

Limiting Values
Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and operation of the device at these or any other conditions above those given in the recommended operating conditions of the datasheet is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and Conditions of Sale
In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NVE hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NVE products by customer.

No Offer to Sell or License
Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export Control
This document as well as the items described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

Automotive Qualified Products
Unless the datasheet expressly states that a specific NVE product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NVE accepts no liability for inclusion or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NVE's warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NVE's specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NVE for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NVE's standard warranty and NVE's product specifications.

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 Fax: (952) 829-9189 www.nve.com

\

An ISO 9001 Certified Company

NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
www.nve.com
e-mail: sensor-info@nve.com

SB-00-076—AG952 Evaluation Kit Manual

December 2018